Comparison between satellite retrieved MBL cloud microphysical properties and Aircraft in situ data

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Satellite results were provided by NASA LARC cloud working

Motivation

- **What can we learn from the in-situ measurements?**
- **Are different MBL cloud microphysical properties always caused by different air masses?**
- **Can different platforms (Satellite, surface radar and aircraft) measure the same MBL cloud microphysical properties?**

Datasets (Summer 2017 and Winter 2018 IOPs over ARM ENA)

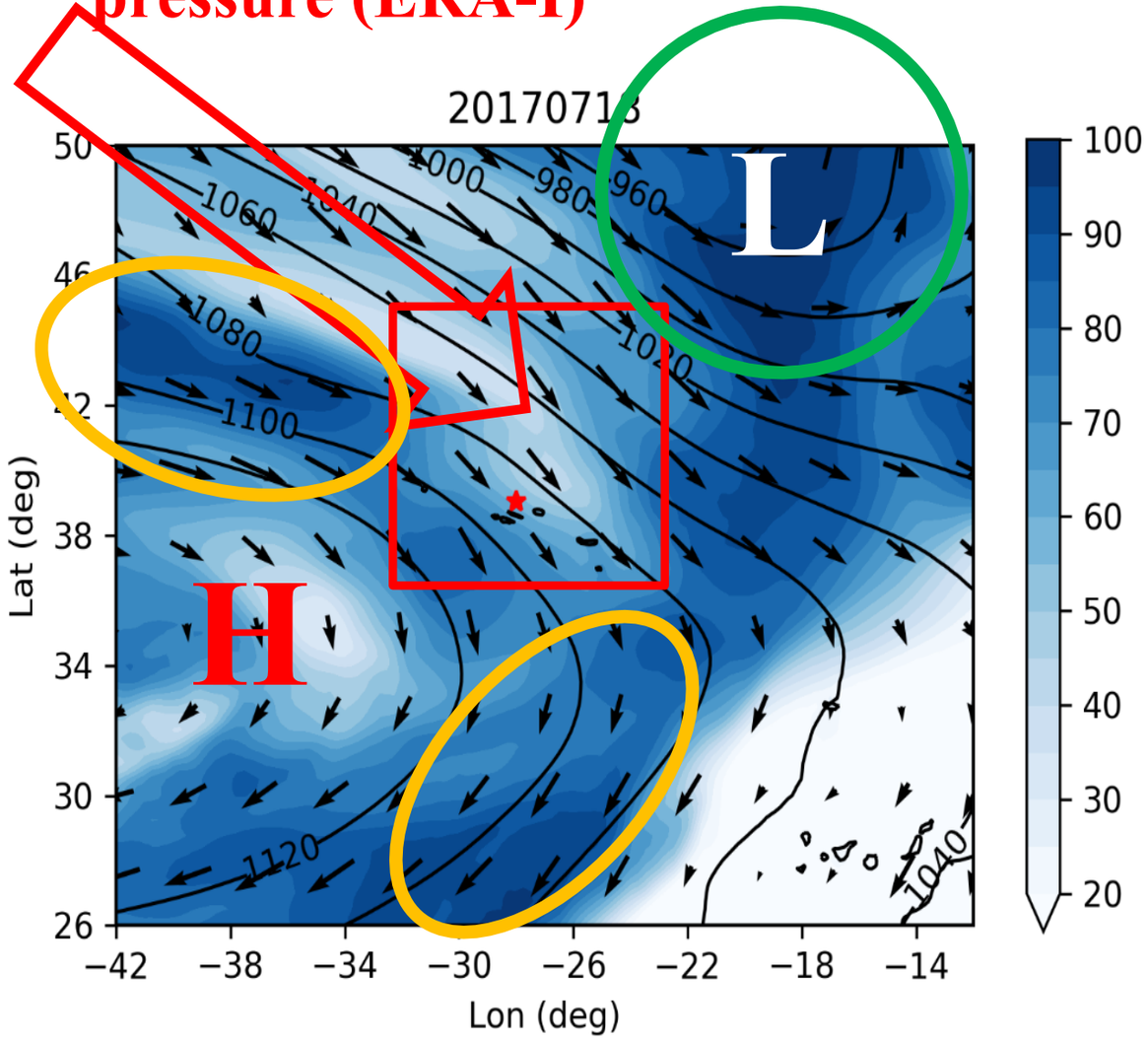
- MeteoSat (METEO) pixel: 4km x 4km
- CERES-MODIS (CM) pixel: 1km x 1 km
- Aircraft in-situ measurements: 1 s (~ 90 m/s)
- Ground-based measurements over ARM ENA site

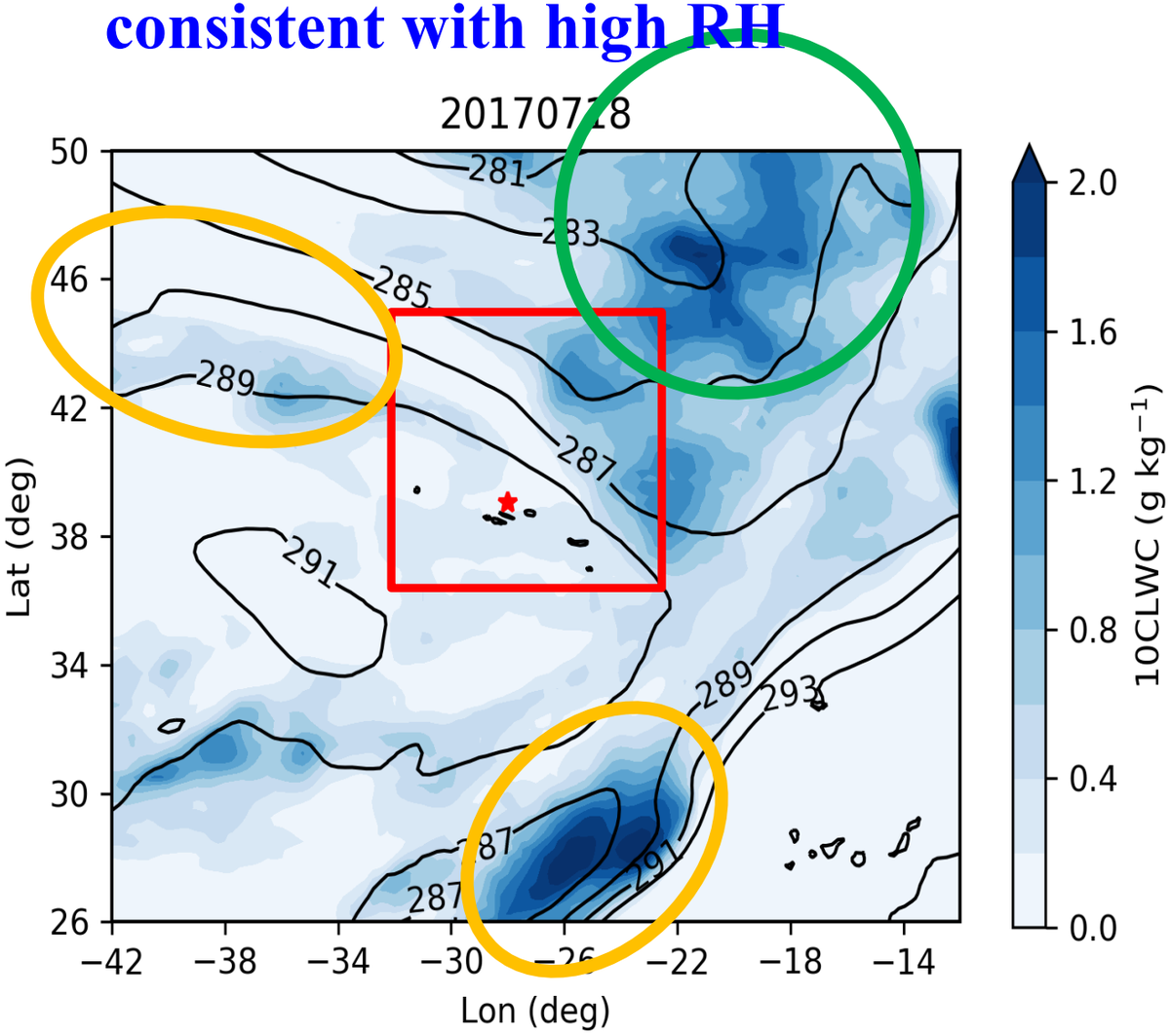
Methods

- A case study: July 18, 2017
- Compare daytime warm clouds (T_{top}>0ºC) MeteoSat pixel-level retrievals with aircraft in situ measurements and radar scanning radar measurements.

A dry region between H and L pressure (ERA-I)

LWC is larger over L pressure➔ consistent with high RH

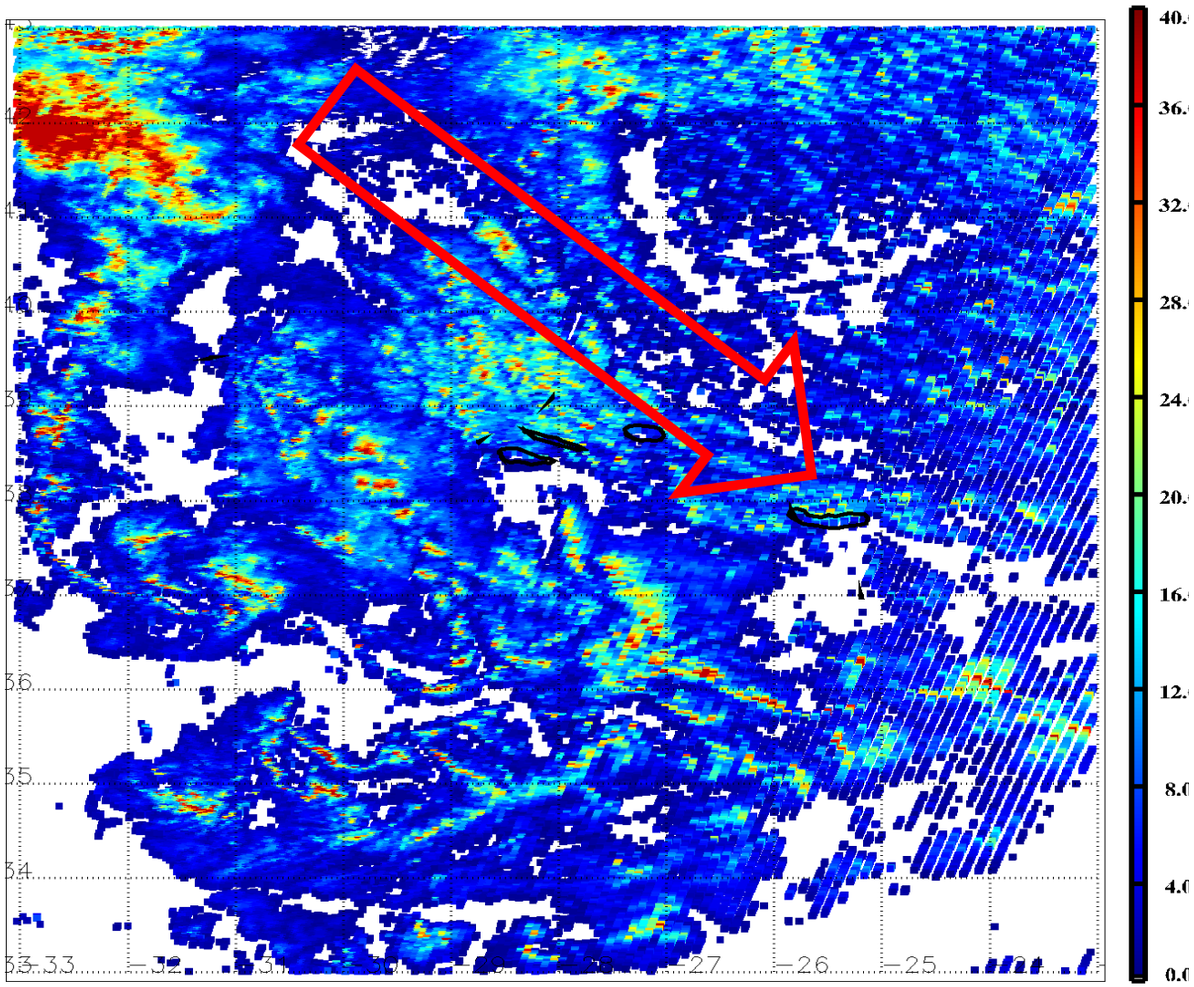




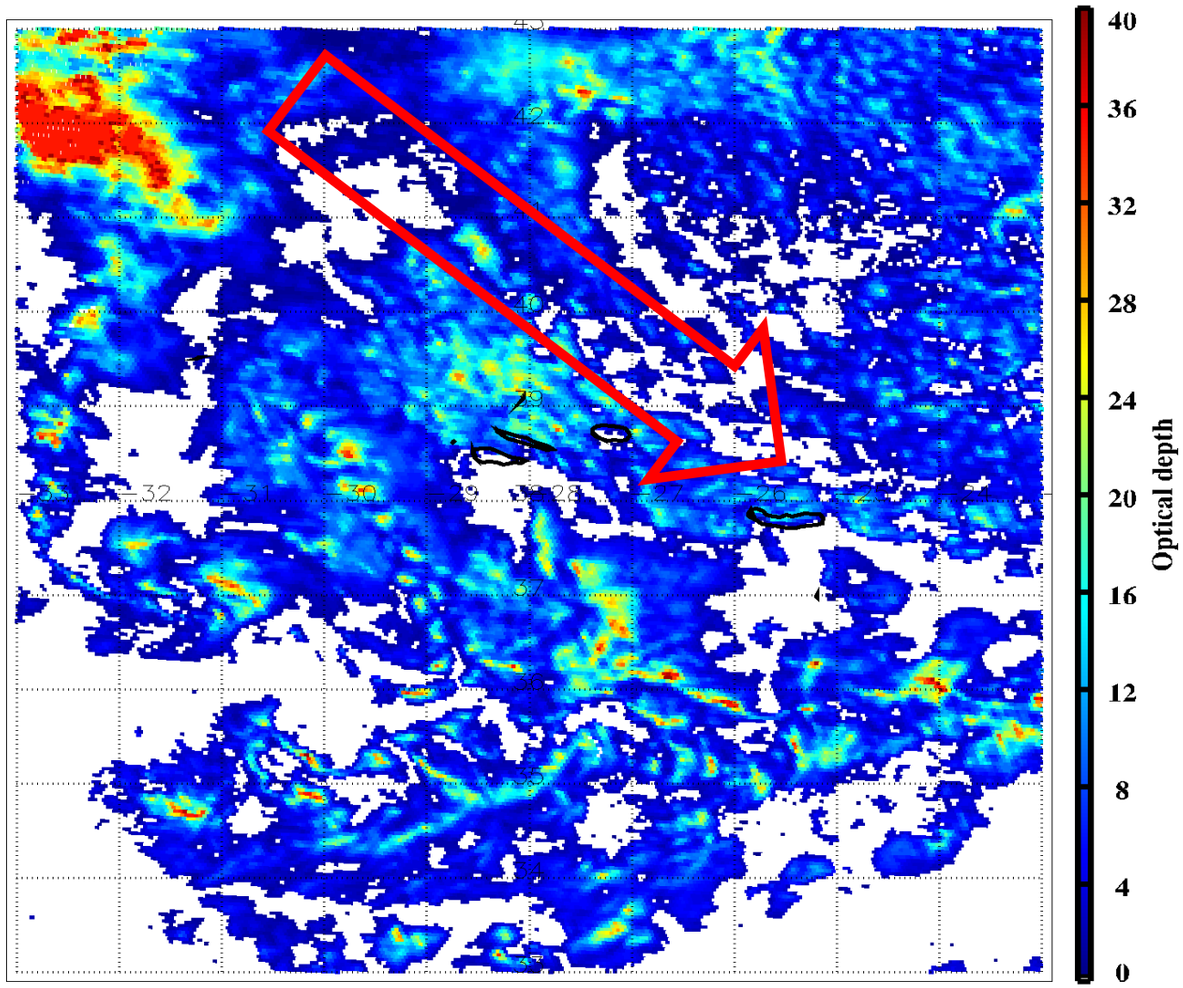
The 24-hr mean synoptic patterns (from ERA-I) show above:
A relatively dry region (Aircraft measurements) falls between the H and L pressures. High LWCs correspond well with high RH values.

Cloud structure was determined by large-scale dynamic pattern

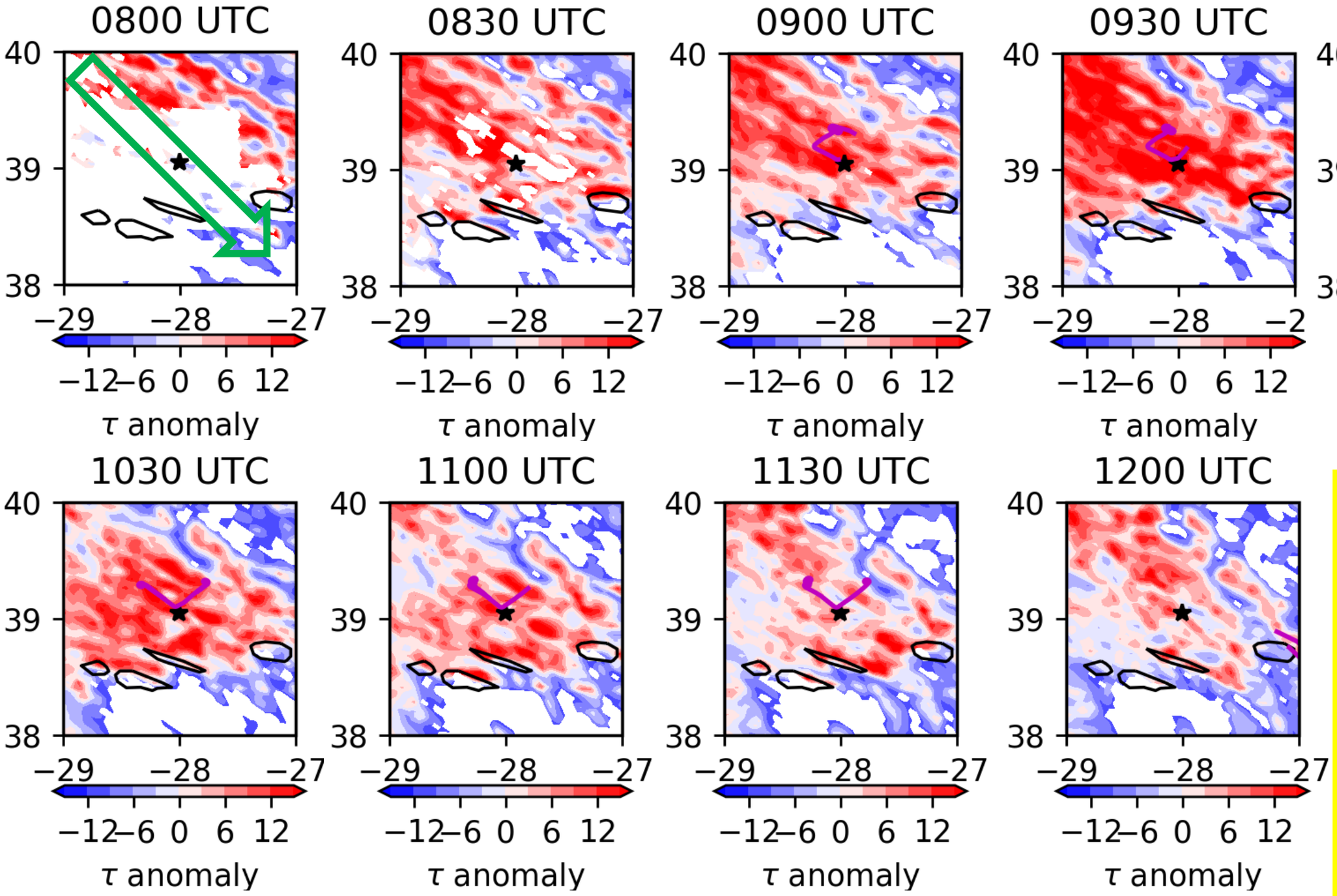
CM optical depth at 13Z



MeteoSat optical depth at 13Z



Both CERES-MODIS and MeteoSat cloud optical depth are shown in 10x10 domain. The overall patterns are very similar to each other.



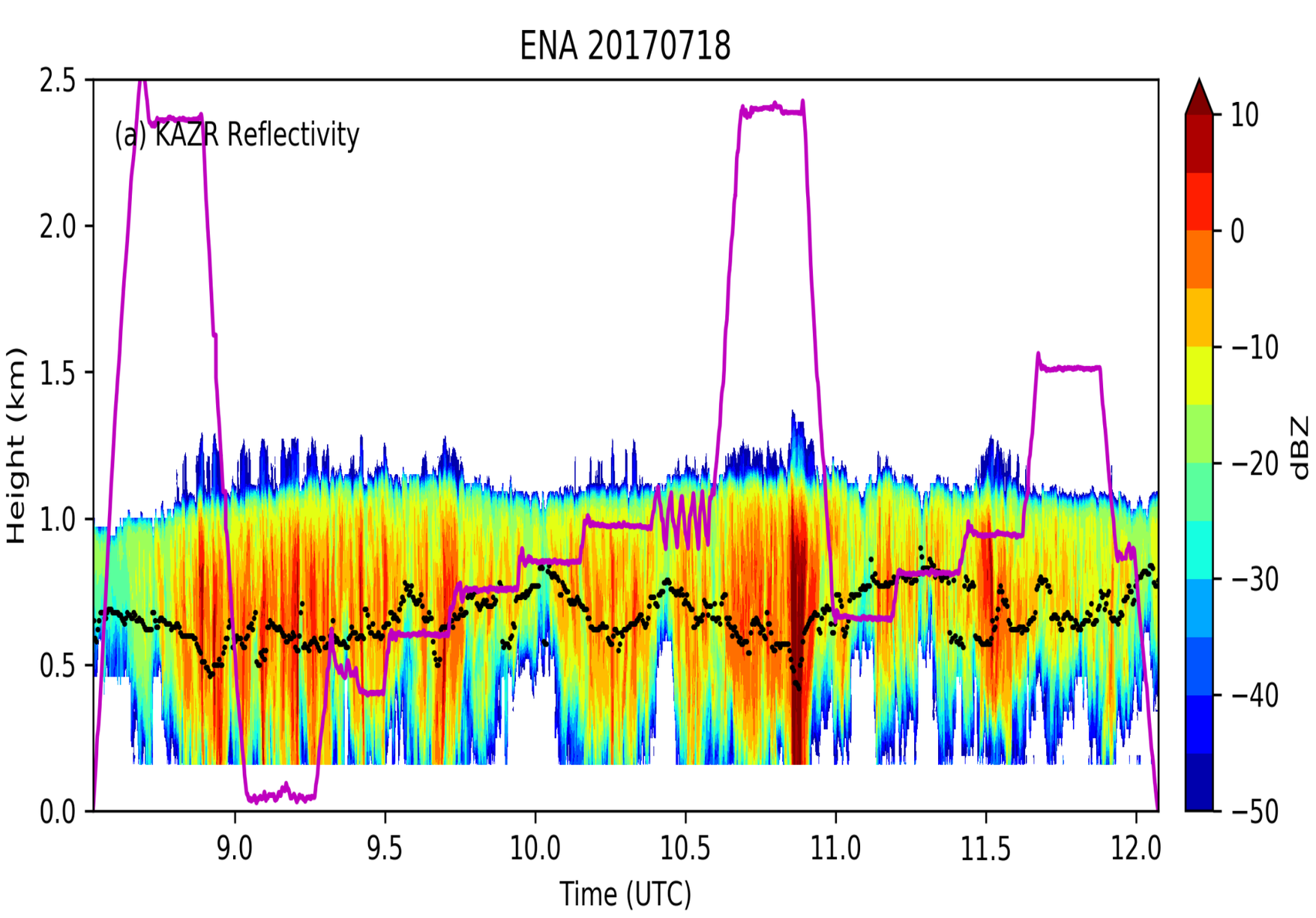
MeteoSat τ anomaly

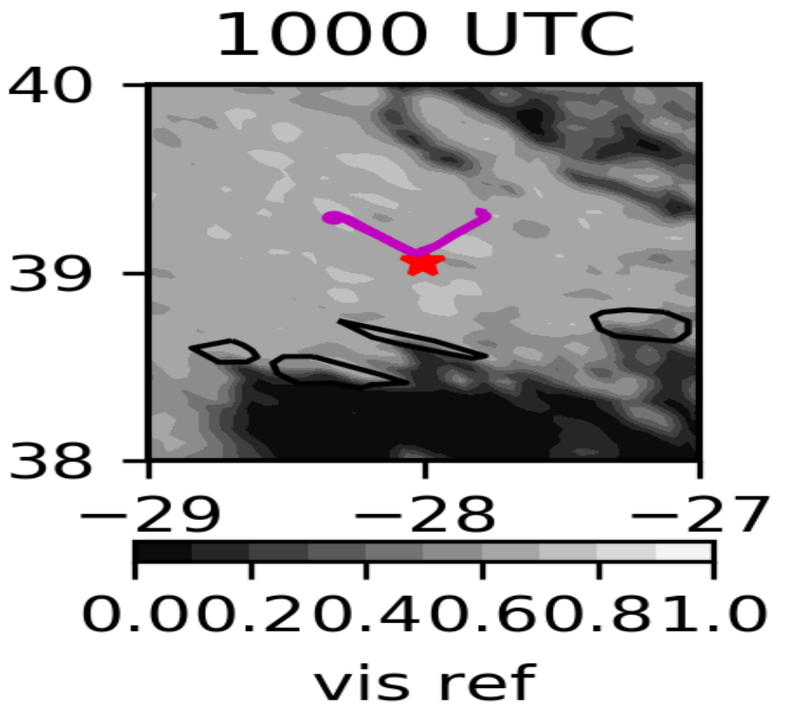
➔clouds move from NW to SE.

➔Clouds form at 8:00, mature at 9:30-10:00, then start dissipation after that.

➔Different cloud streets parallel to wind direction.

Case Study 20170718: Radar Reflectivity and Meteosat

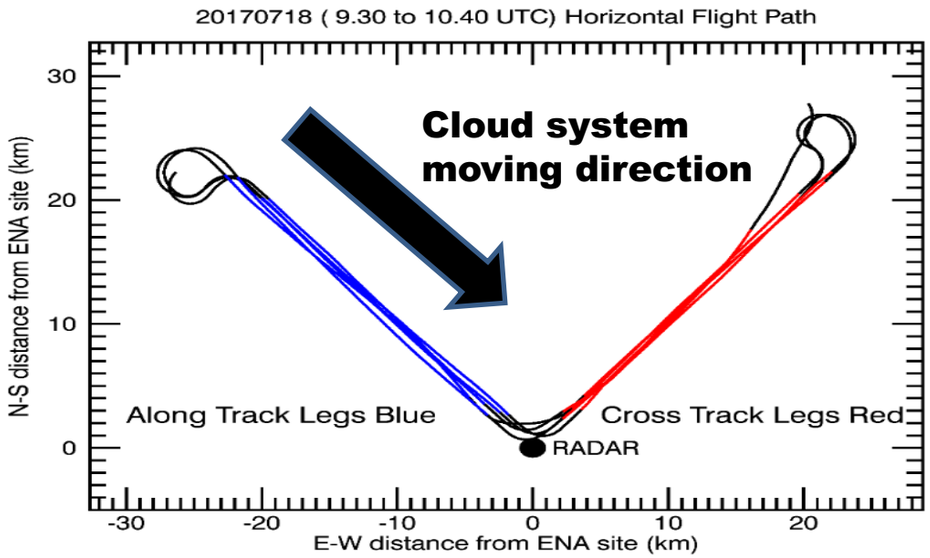


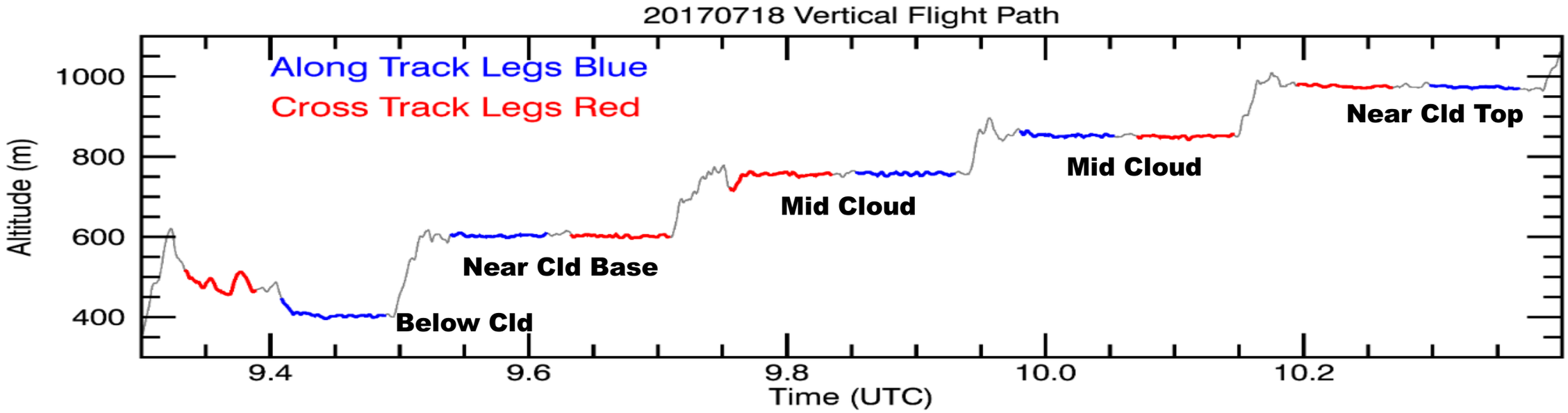


- **This is a drizzling MBL cloud layer with relative small variations of cloud top and base heights.**
- **Aircraft flew from below cloud base to above cloud top at different heights.**

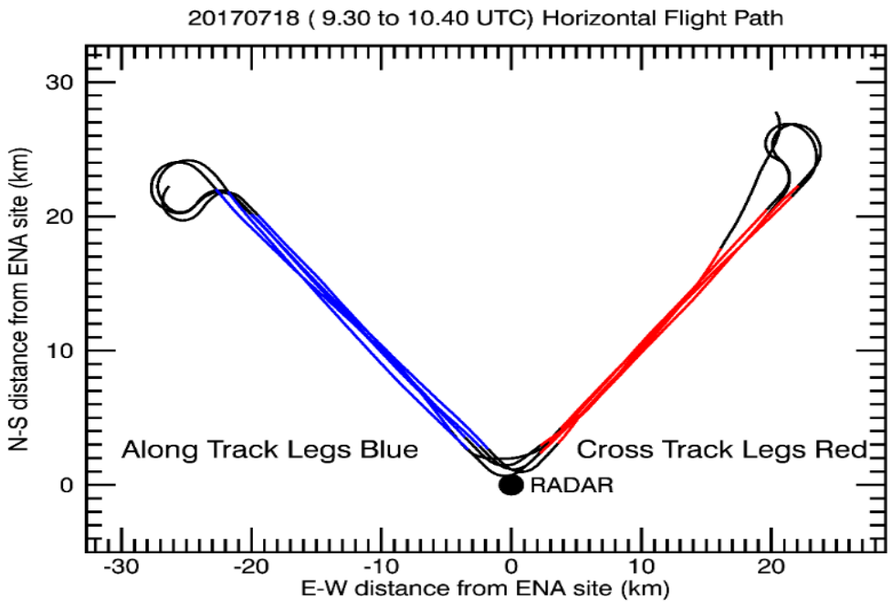
Cloud microphysical properties Along and Cross cloud system (Case study: July 18, 2017)

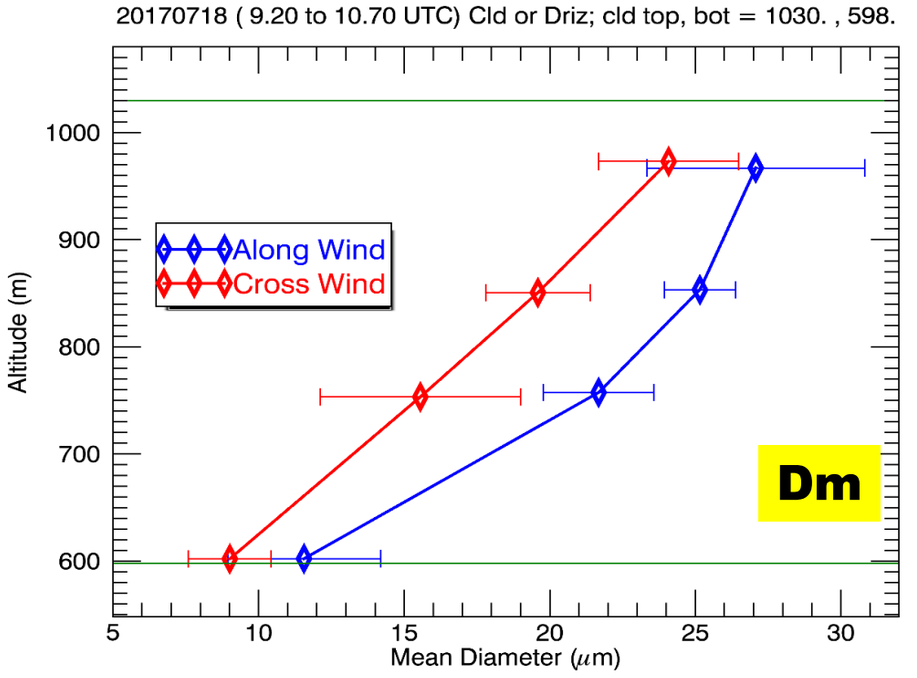
- **Aircraft flew "L – shaped" horizontal patterns along successively higher altitude tracks**
- **One leg of the "L" is lined up with cloud system (blue segments), while other leg of "L" is across cloud system (red segments)**

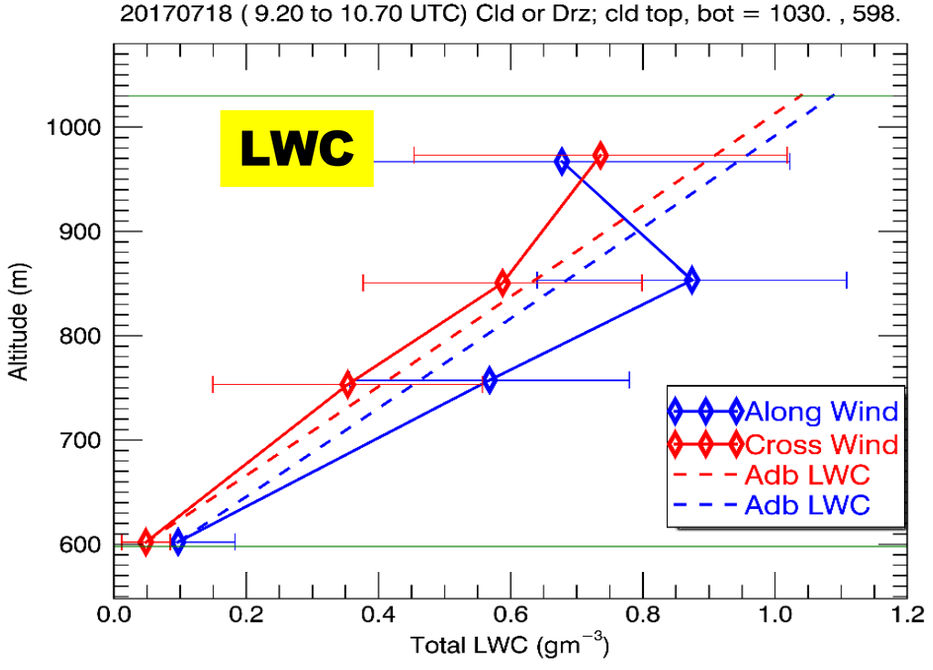


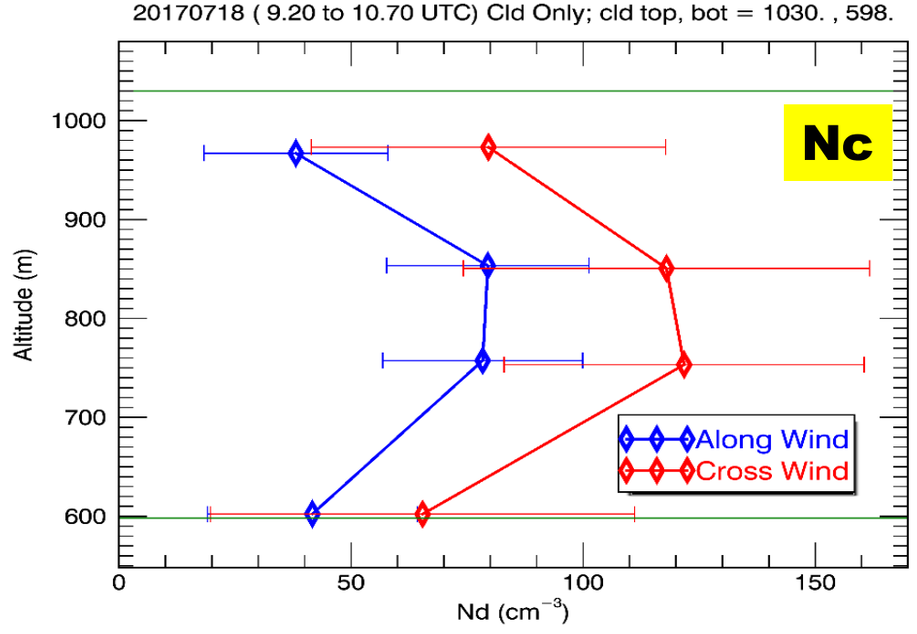


Cloud microphysical properties Along and Cross cloud system (Case study: July 18, 2017)







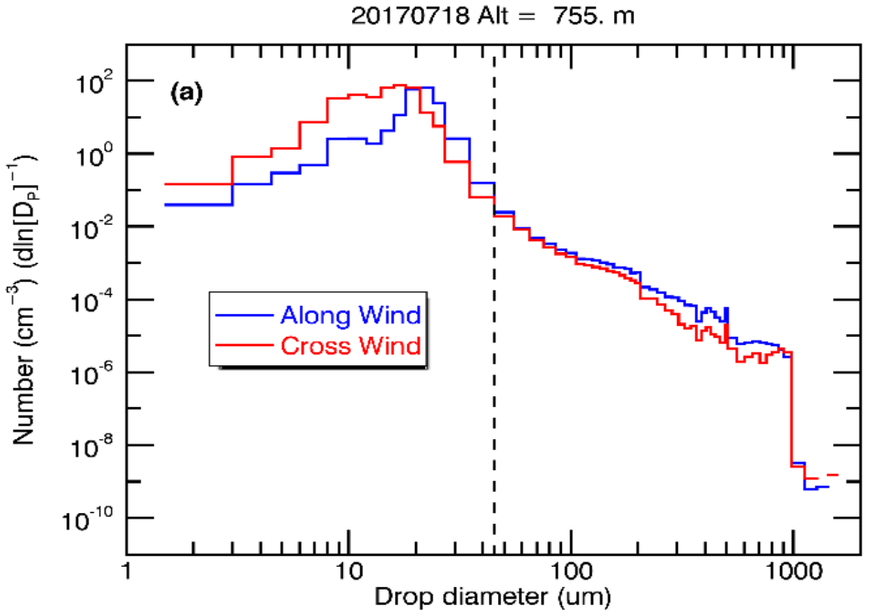


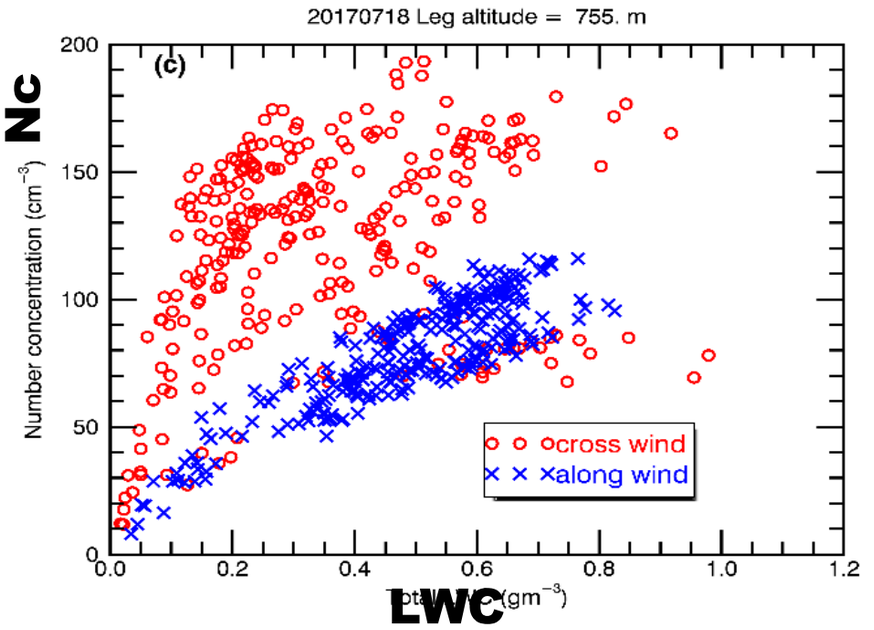
LWC and D_m increase from base to top. Max N_c in center.

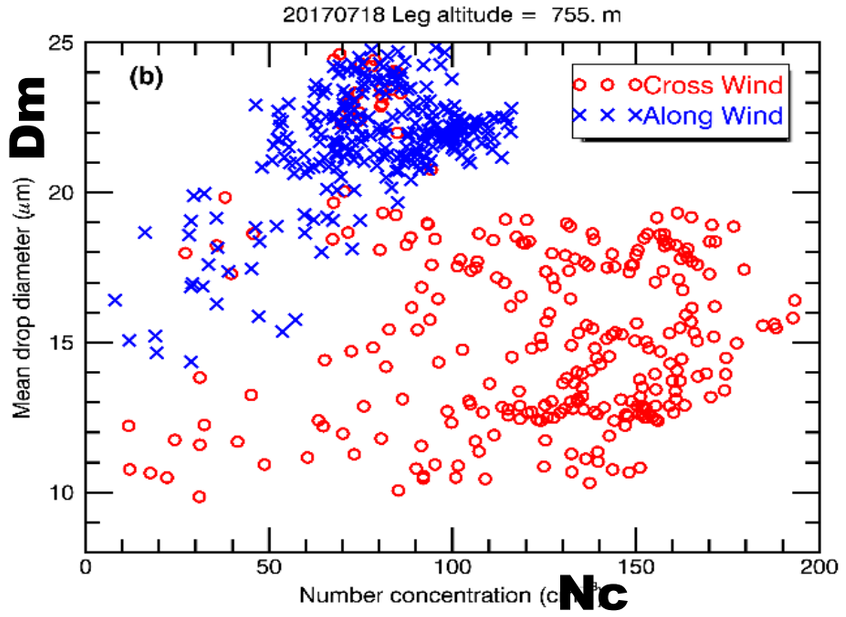
Along cloud system has larger LWC and Dm, and lower Nc than those cross cloud system.

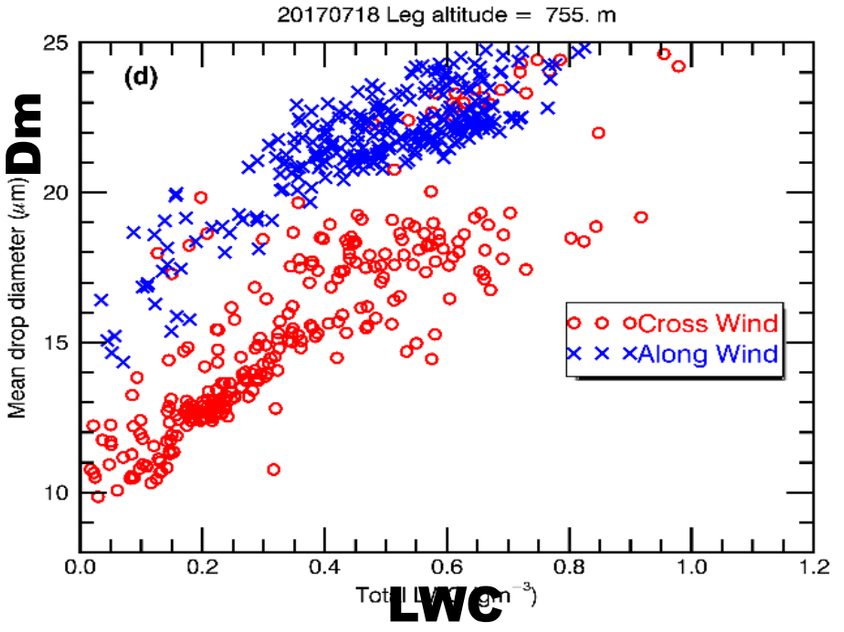
Standard deviations from cross are larger →broader DSD.

Cloud Droplet Size Distributions (DSDs) Along and Cross cloud system at an altitude of 755m







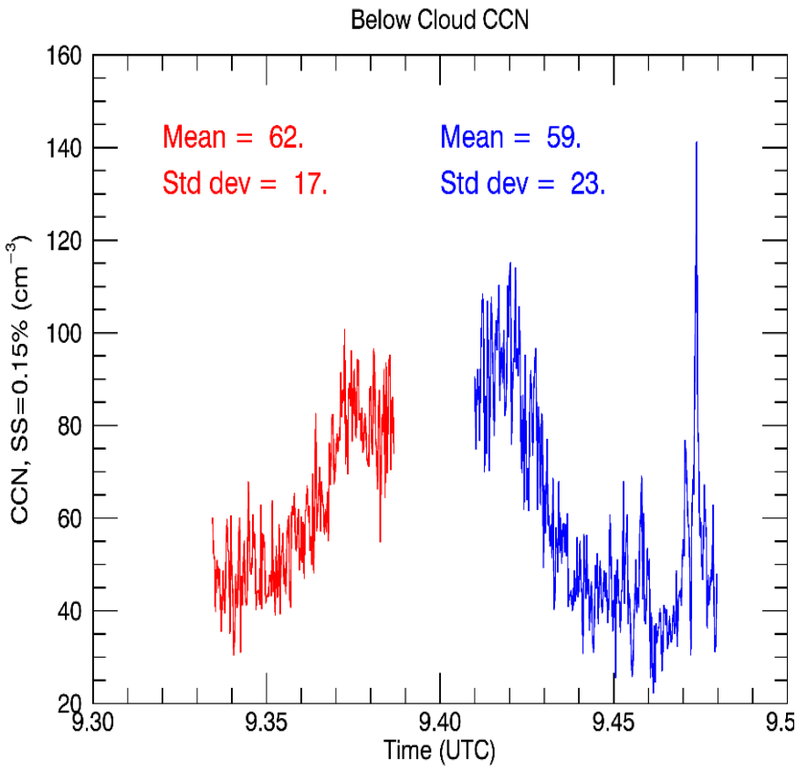


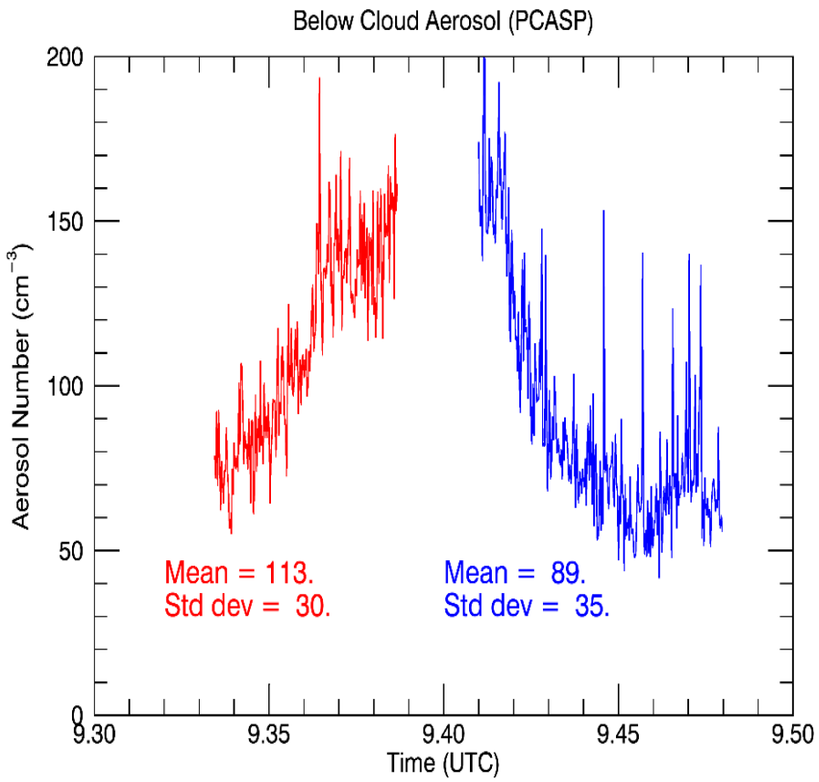
(a) Along wind has fewer droplets Dm< 45 μm and more drops Dm > 45 μm

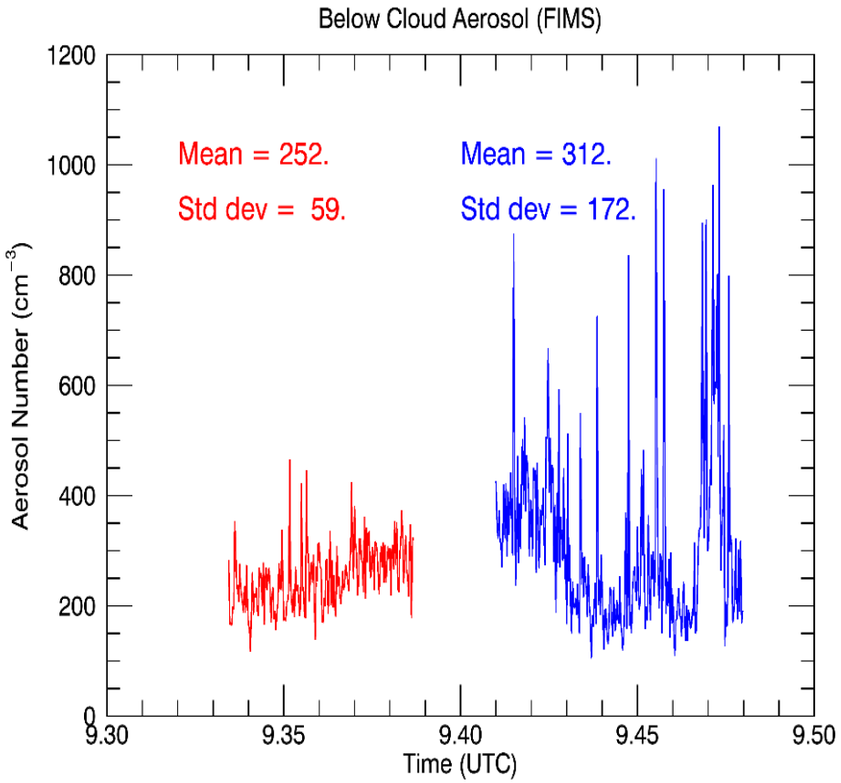
(b) There are two obvious groups of cloud properties along and cross wind.

(c)-(d) Both Dm and Nc increase with LWC.

Different microphysical properties are not likely due to different air masses



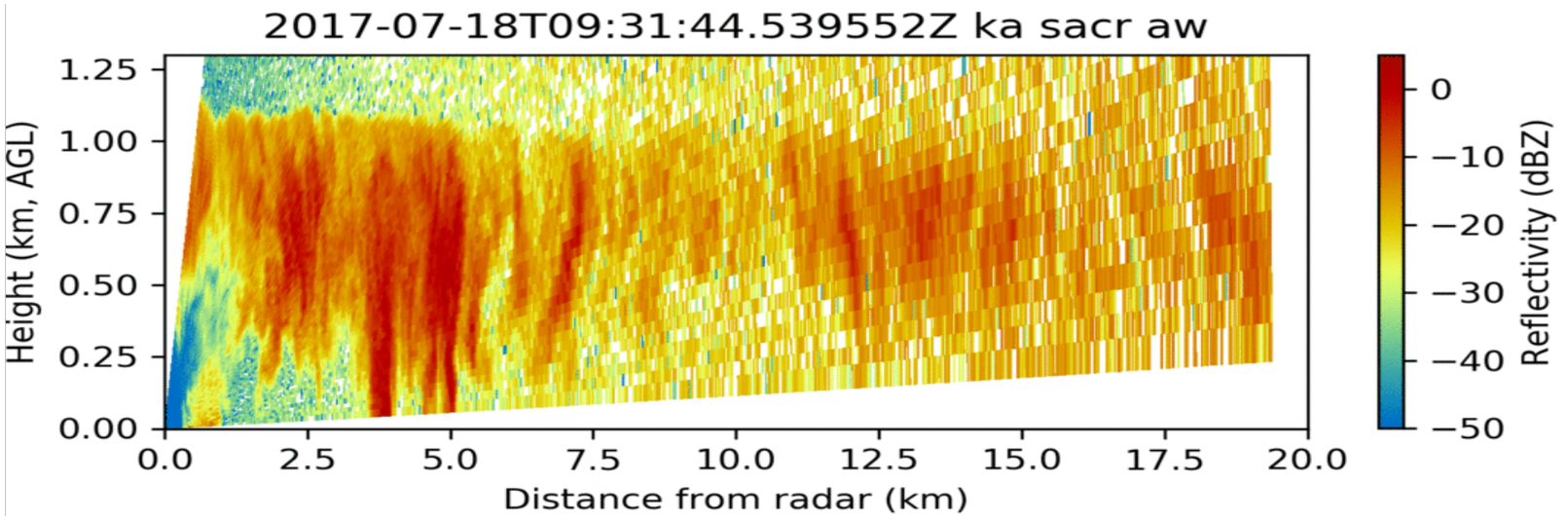


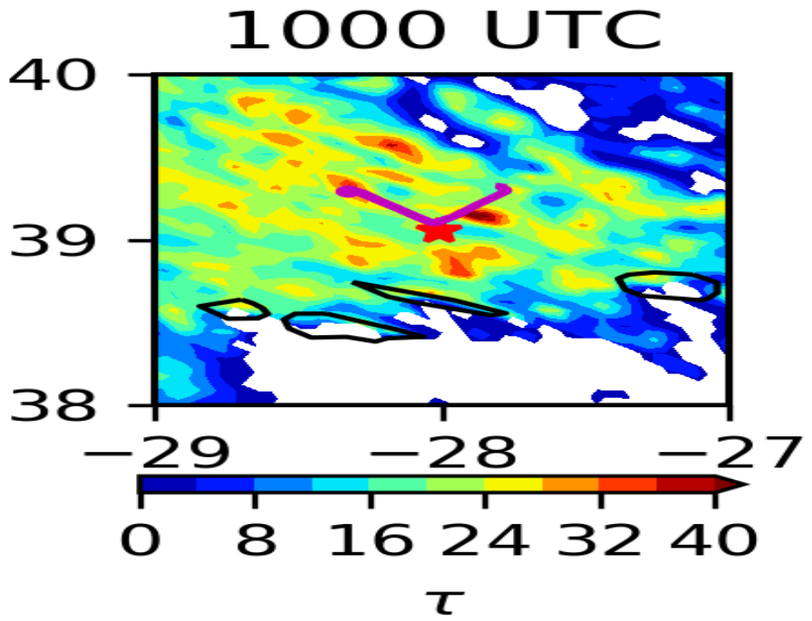


- **1s observations of CCN and aerosol concentration from the below cloud base flight legs.**
- **Along and cross track paths are within 40 km of each other, so large-scale air mass expected to be the same.**

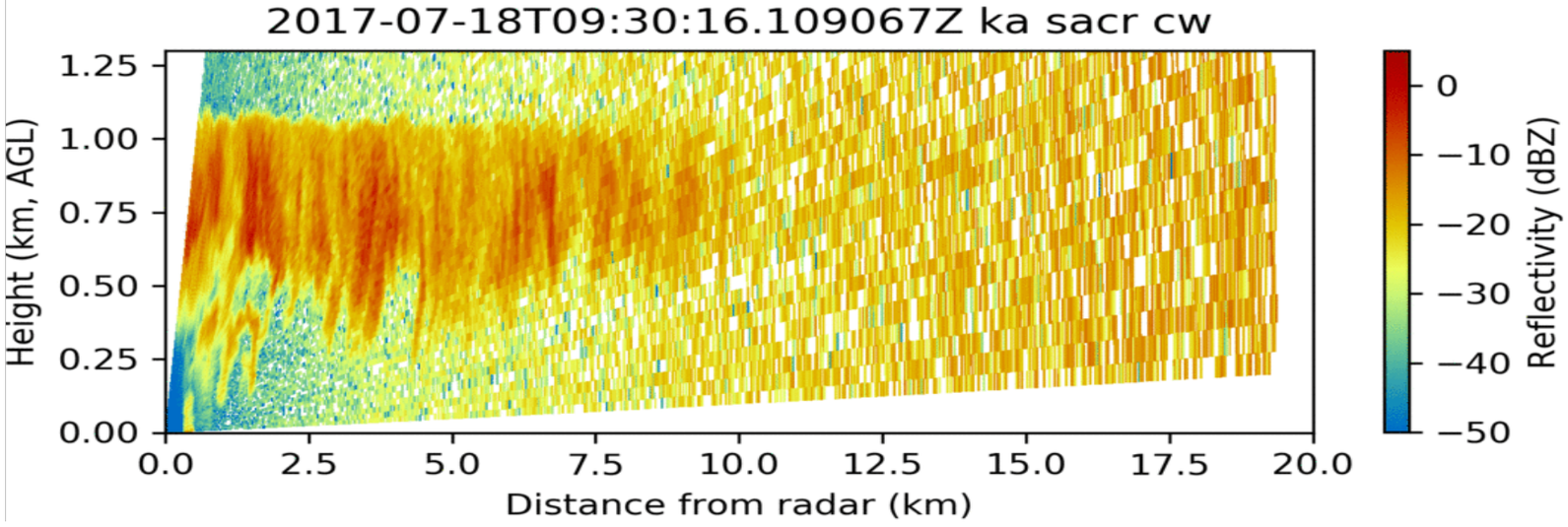
Different microphysical properties due to sample two cloud streets/systems

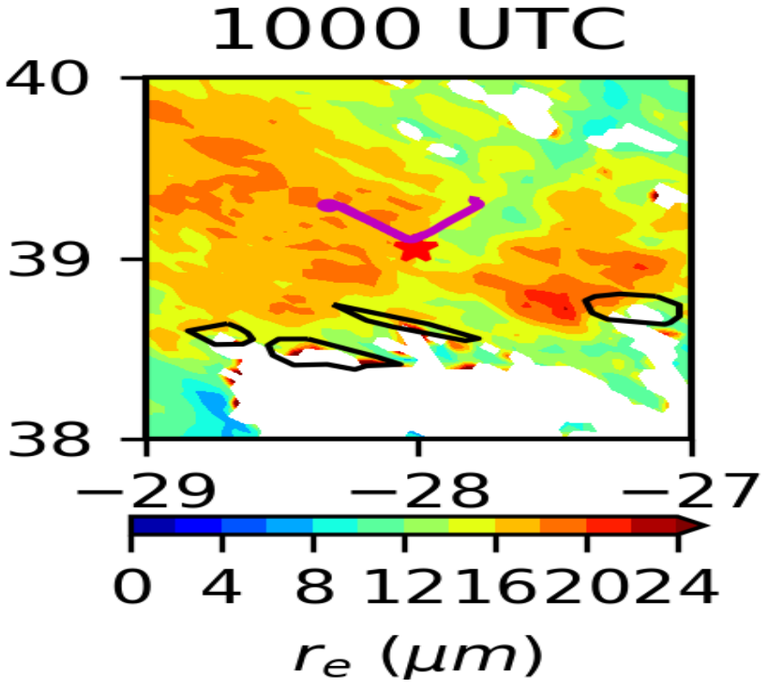
Along Wind flight (cloud moving toward to radar)

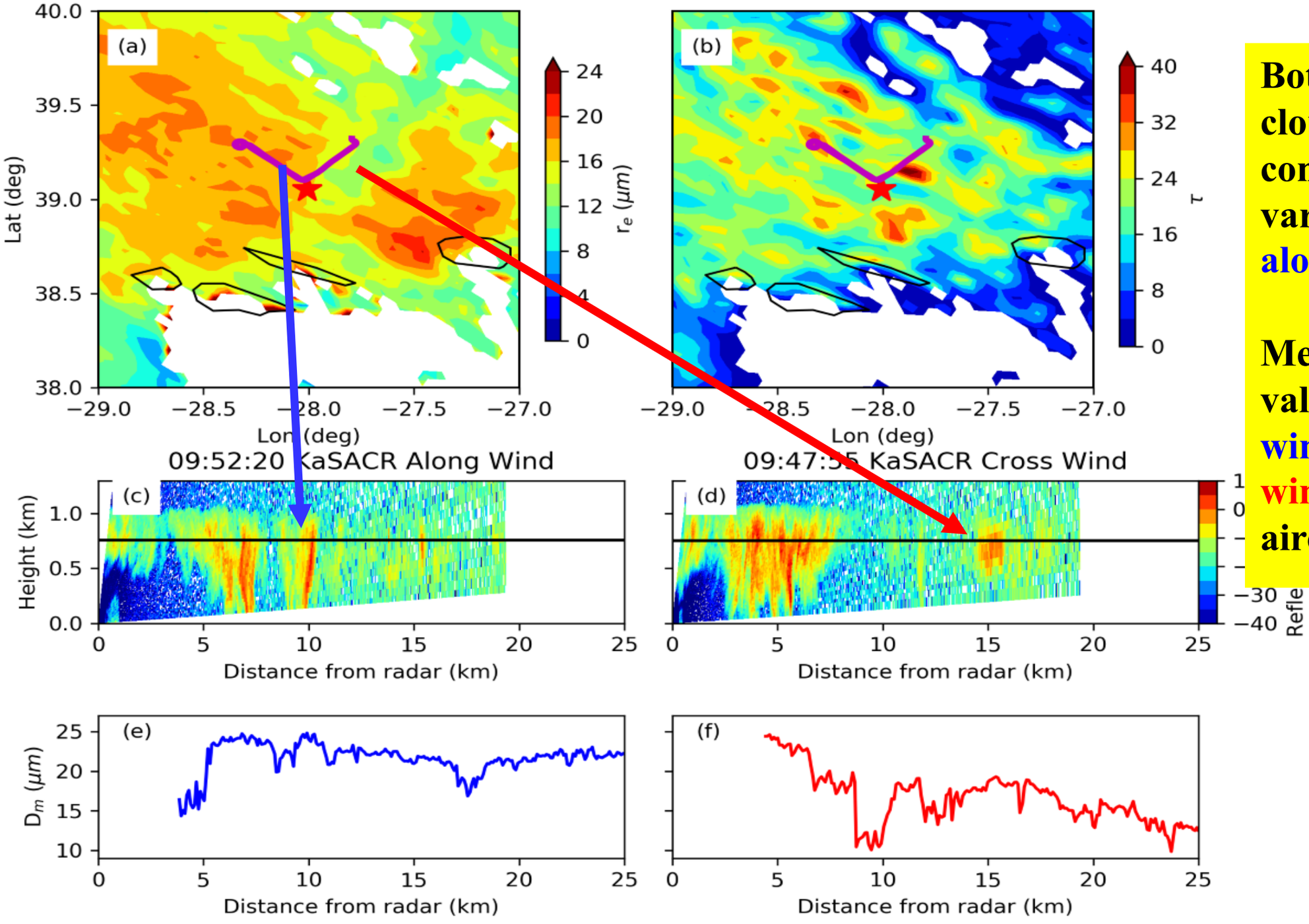




Cross Wind flight (observe different cloud street)



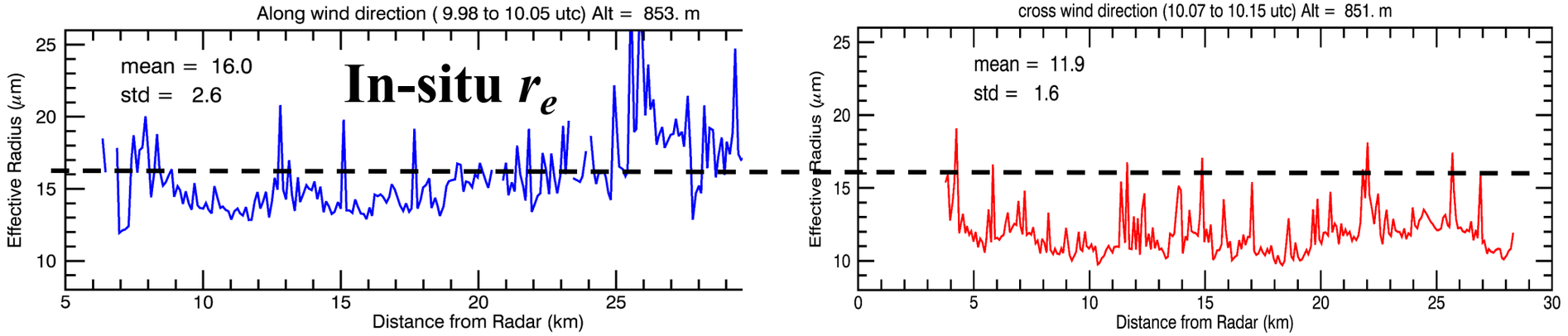


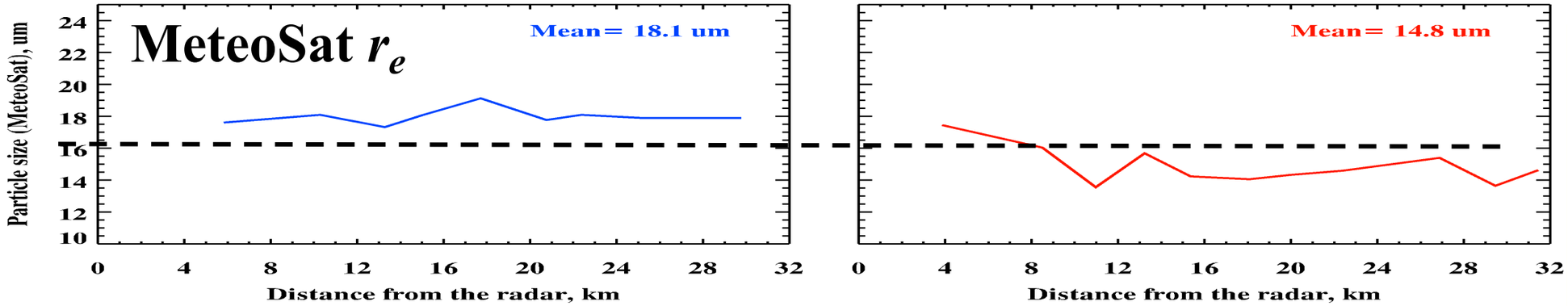


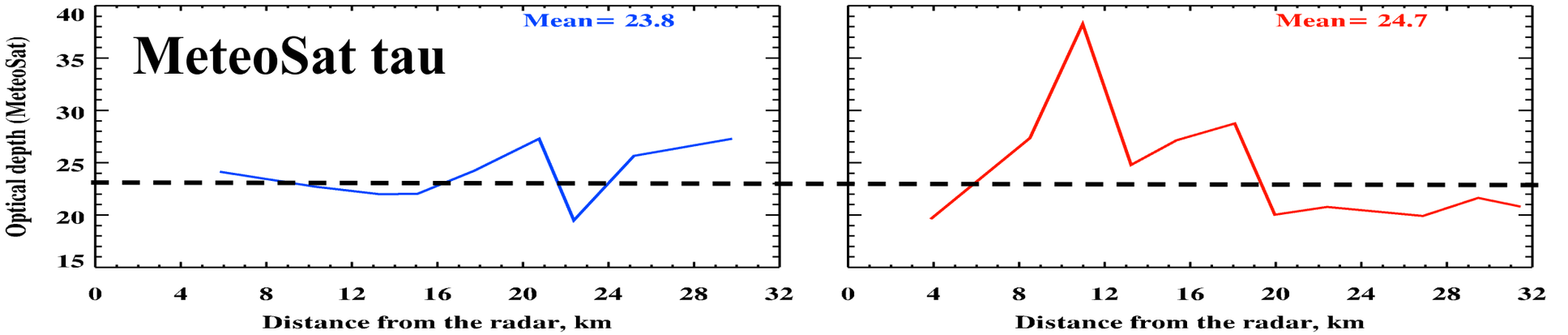
Both MeteoSat and cloud radar show very consistent particle size variation for both along and cross wind.

MeteoSat retrieved r_e values are large along wind and small cross wind, consistent to aircraft in situ data.

Matched MeteoSat Pixel retrievals with Aircraft measurements







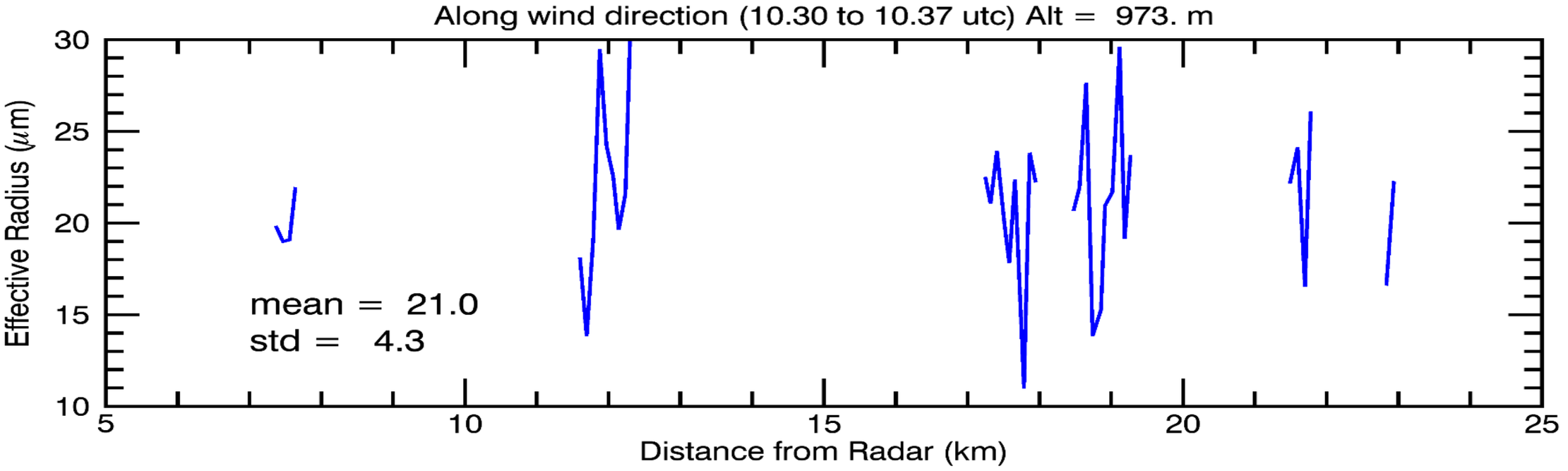
MeteoSat retrievals in both directions follow well with in-situ measurements.

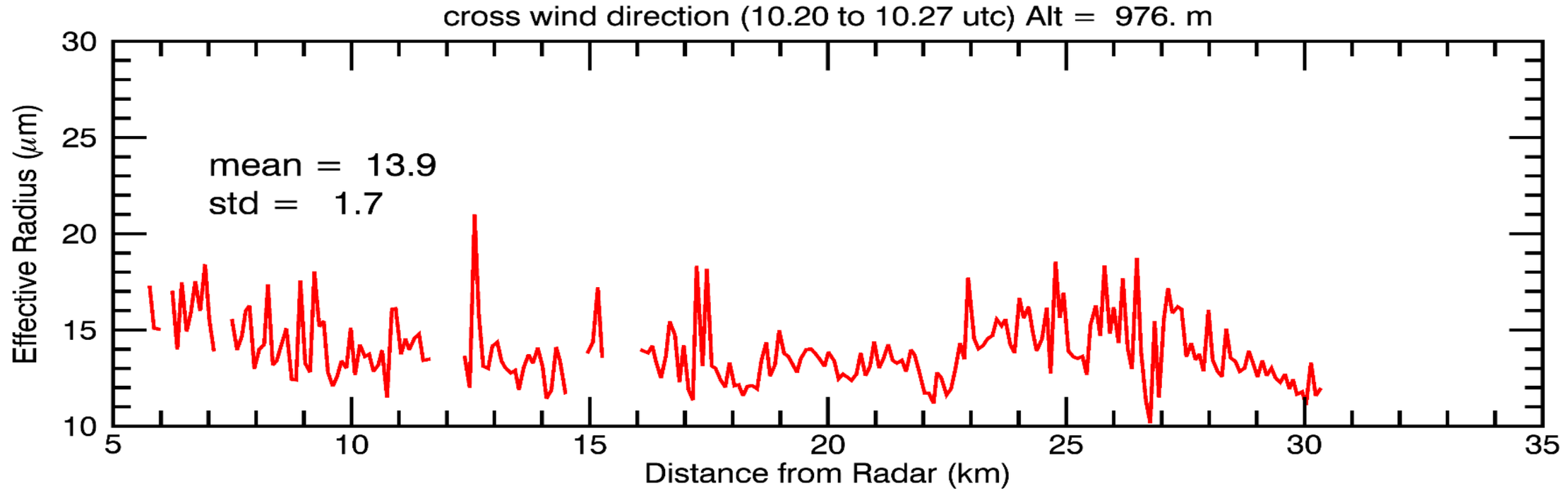
Summary

- **Aircraft captured two cloud streets with different microphysical properties. This characteristics were also observed by ARM scanning radar and MeteoSat observations.**

- **Different microphysical properties along and cross wind directions are not caused by aerosol properties (they are same along and cross winds).**

- **The MeteoSat retrieved cloud particle sizes match well with aircraft in situ measurements near cloud top.**


Along wind direction (10.30 to 10.37 utc) Alt = 973. m
Effective Radius (μm)
Distance from Radar (km)
mean = 21.0
std = 4.3
30
25
20
15
10
5
10
15
20
25


cross wind direction (10.20 to 10.27 utc) Alt = 976. m
Effective Radius (μm)
Distance from Radar (km)
mean = 13.9
std = 1.7
30
25
20
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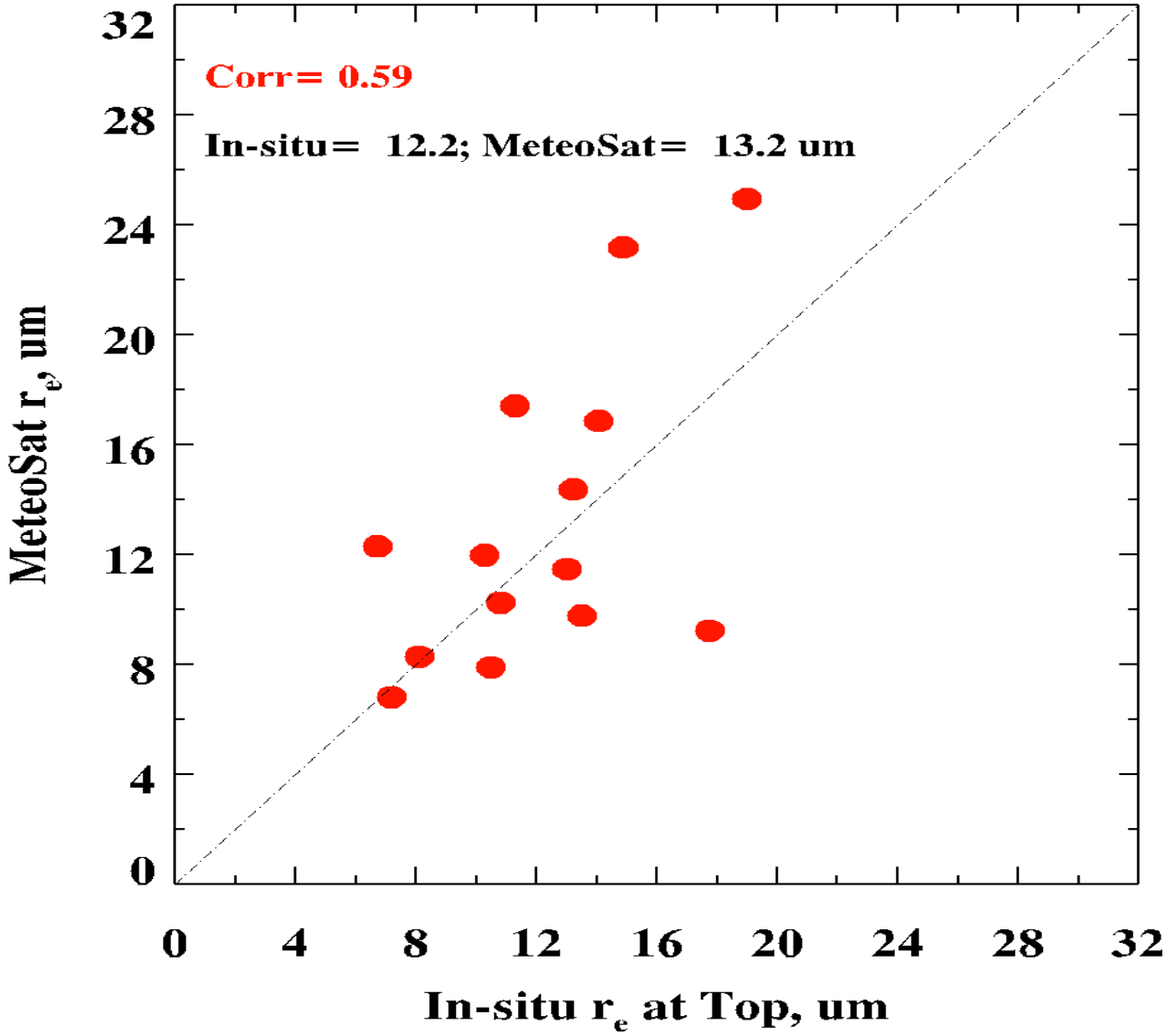
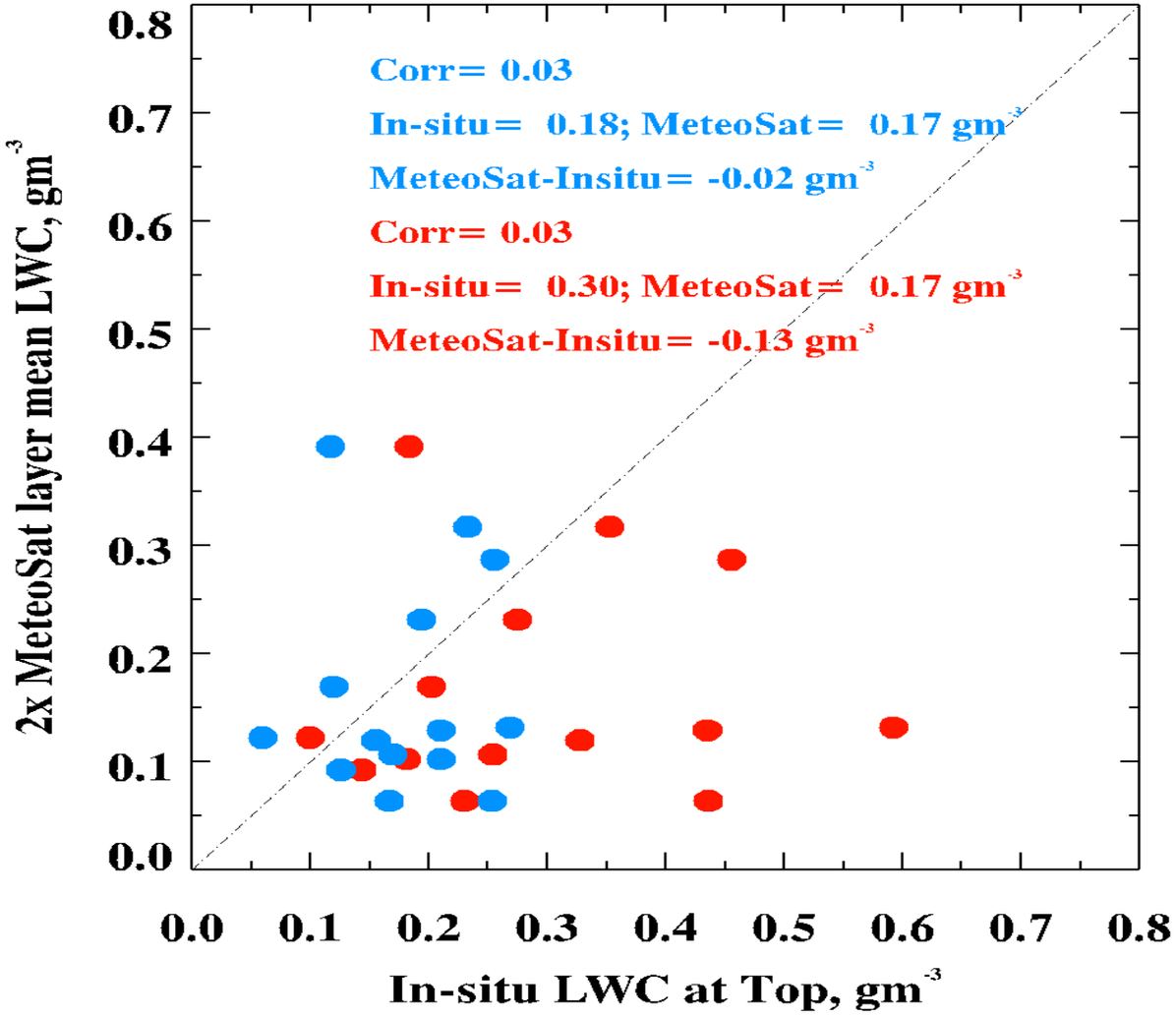
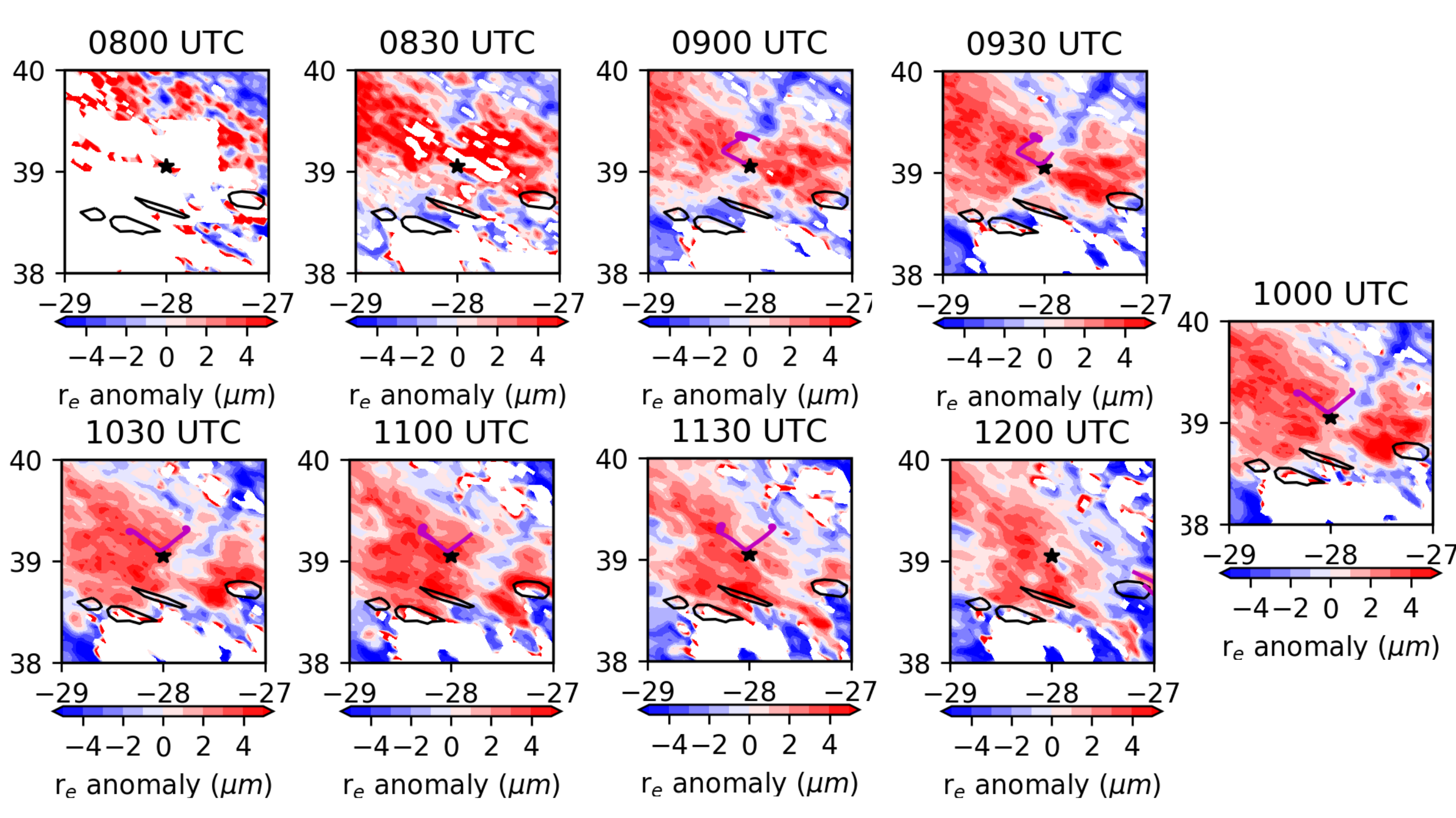
35





In-situ re is from FCDP measurements at the cloud top; a total of 14 cases
MeteoSat mean LWC is calculated using 2*LWP/(Z_{top}-Z_{base});
In-situ LWC (red) is calculated using FCDP measured N_c and particle size


0800 UTC
0830 UTC
0900 UTC
0930 UTC
1000 UTC
1030 UTC
1100 UTC
1130 UTC
1200 UTC
40
39
38
−29
−28
−27
−4 −2 0 2 4
r$_e$ anomaly (μm)